Evaluation with CALIPSO lidar observations of the global cloud cover obtained from geostationnary data in the frame of the MEGHA-Tropiques mission

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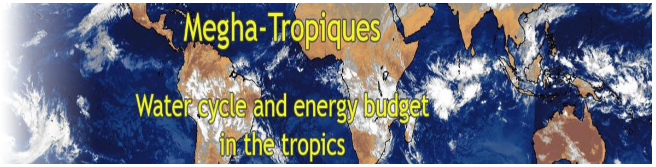
- The elaboration of coherent cloud mask, cloud type classification and cloud top pressure maps with a high spatial and temporal resolution in the tropical belt using geostationary satellite data (GOES-E, GOES-W, MTSAT and SEVIRI/Meteosat).

- First evaluation of these clouds fields: comparison of cloud cover type and cloud top pressure for with CALIOP lidar data.

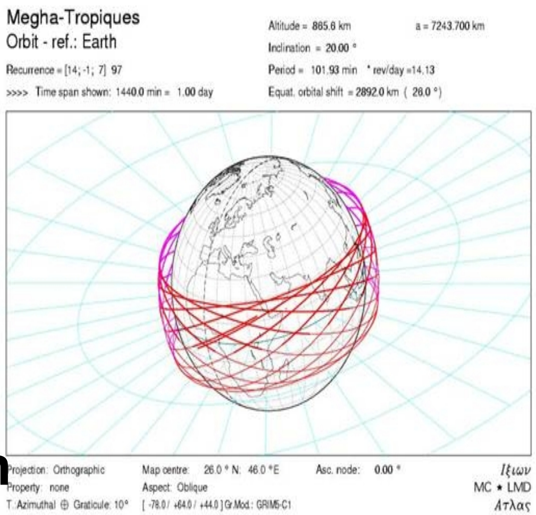


THE MEGHA-TROPIQUES MISSION

ISRO/CNES mission

MEGHA-TROPIQUES aims to measure with a high repetitivity radiances linked to radiative fluxes, water vapour and precipitation:

The 20 degree orbit at 870km of altitude allows up to six observations by day of the same region.



A MW imager for rain and clouds (MADRAS),
a MW sounder for water vapour (SAPHIR) and
a wide band instrument for radiative fluxes (ScaraB)

The geostationary satellite VIS and IR imagers will complete this set of instruments for the cloud scene identification and cloud top pressure retrieval at high spatial scale, the tracking of cloud convective systems, the multi-instrument precipitation retrieval.

The cloud scene identification and cloud top pressure will be used:

- as input in the SAPHIR-MADRAS water-vapour profile retrieval.
- for the validation of the ScaraB cloud scene classification
- to better characterize clouds associated to convective systems
- to observe the low cloud cover

Elaboration of cloud cover maps over the tropical belt using geostationary satellite data

➔ **Multi-spectral threshold technique developed for the radiometer SEVIRI on board MSG by the *Satellite Aplication Facility for NoWCasting* (Hervé Legleau and Marcel Derrien, 2005)**

➔ **5 satellites in the minimal configuration with at least one visible channel, two IR channels (10.8µ, 3.9µ), one WV or CO2 sounder channel**

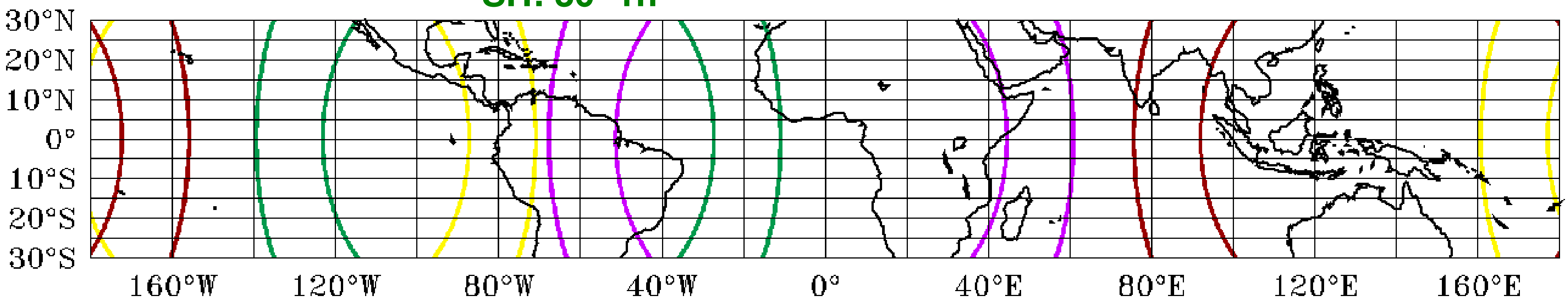
GOES-W
4km
G: 3h - NH: 30'
SH: 30'-1h

GOES-E
4km
G: 3h - NH: 30'
SH: 30'-1h

MSG
3km
G: 15'

futur:
INSAT-D
5km
G: 1h

MTSAT
4km
G: 1h- NH:30'



G=Global N=North hemisphere S=South hemisphere NR=North region SR south region

The colour curves indicate for each satellite the 72.5° VZA and 55° VZA.

The retrievals (1)

Clouds are detected in each pixel of the image and classified using multispectral theshold techniques :

✓**Thresholds are computed using :**

- **Atlas: height map**
  land/sea mask
- **Climatological maps: SST** (provided by P. Leborgne, SAF...)
  continental visible reflectance
- **NWP short range forecast data (ECMWF used):**
  surface temperature,
  integrated atmospheric precipitable water
  vertical temperature and humidity profile

✓**Thresholds tuned to radiometer's spectral characteristics with Radiative Transfer Models in cloud free conditions (6S,RTTOV).**

All these input have been adapted to spectral characteristics and field of view of SEVIRI, GOES-E,GOES-W, MTSAT and FY-2C.

The retrievals (2)

Cloud top pressure is extracted using RTTOV simulated radiances; Method depending on cloud type (known from the cloud type classification).

For opaque cloud top: best fit between the simulated and measured 10.8μm radiances excepted for low cloud top in case of temperature inversion.

For thin cirrus cloud: a window channel (10.8) and a sounding channel (13.4μm, 7.3μm or 6.2μm). Two methods, Intercept method and radiance ratioing (Schmetz,1993; Menzel, 1983) are applied.

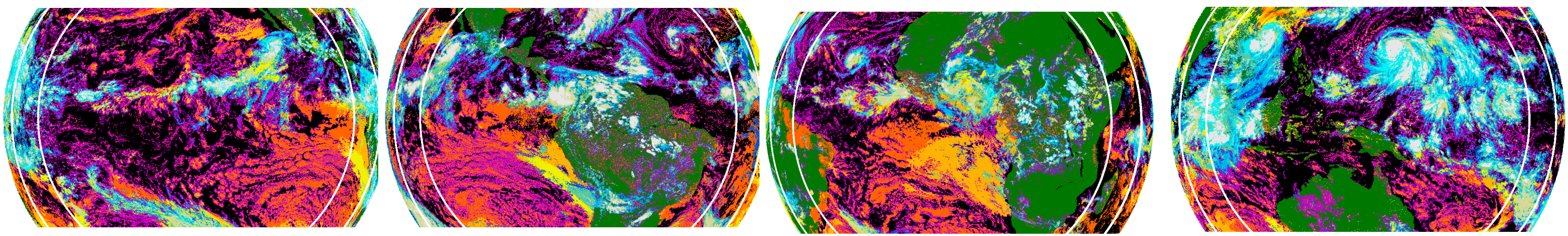
For broken low clouds and multi layer clouds (daytime): No technique has yet been implemented.

Cloud top temperature & height are derived from their pressure

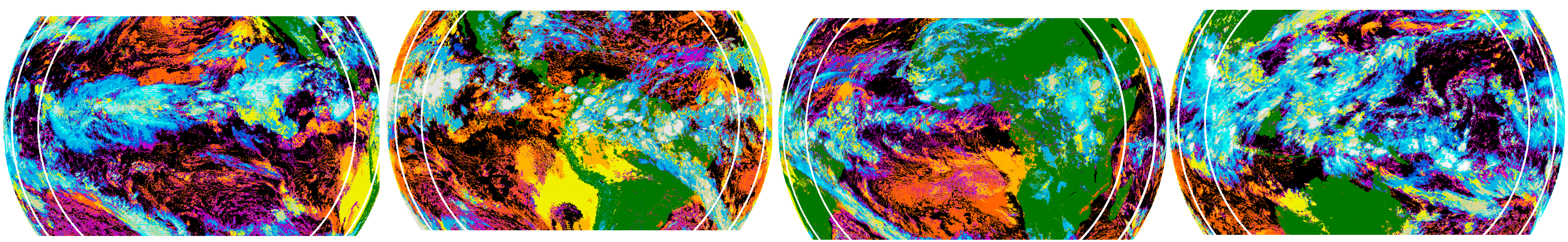
CLOUD TYPE CLASSIFICATION

15 September 2009 daytime data

GOES-W 4 channels GOES-E 3 channels SEVIRI 5 channels MTSAT 4 channels



3 July 2009 nighttime data



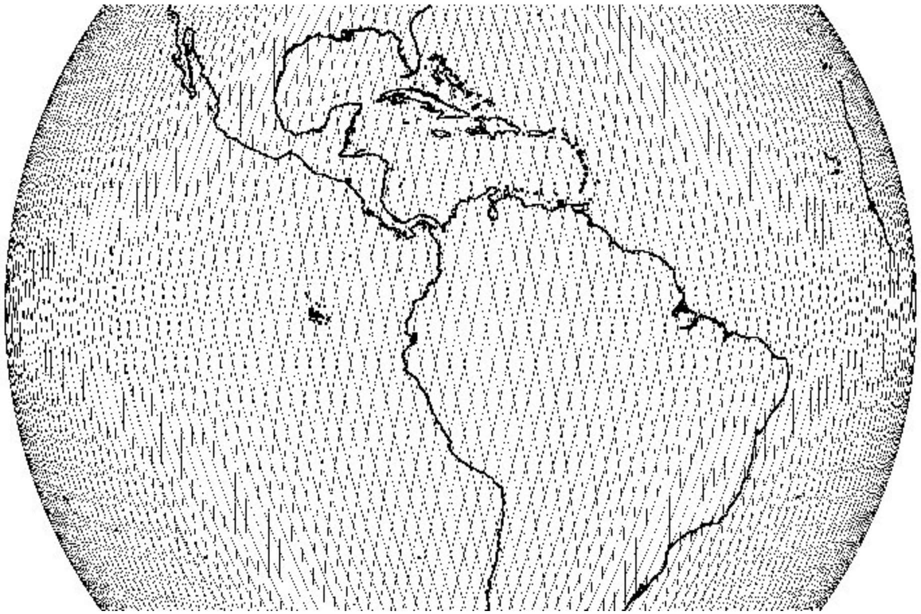
Land Sea Very Low Low Medium High Very Hig. Th. Cir. Cirrus Thk. Cir. Th. Above Partial

White lines: 55° VZA and 72.5 VZA boundaries

Coincident VIS-IR GEOSTATIONARY and CALIOP LIDAR DATA Analysis

For a four month period (June to September 2009) the SEVIRI, GOES-E, GOES-W and MTSAT cloud classification and cloud top pressure data have been collocated on the CALIOP foot print. About 300 CALIOP orbits for one month period and a Geostationary satellite.

The version 3 of the CALIOP 5km average profile and 333m cloud layer operational product is used.



CALIOP DAY and **NIGHT** overpass time: **1h30 am/pm local time.** Mean lag between the GEO and CALIOP observation depends on the GEO.

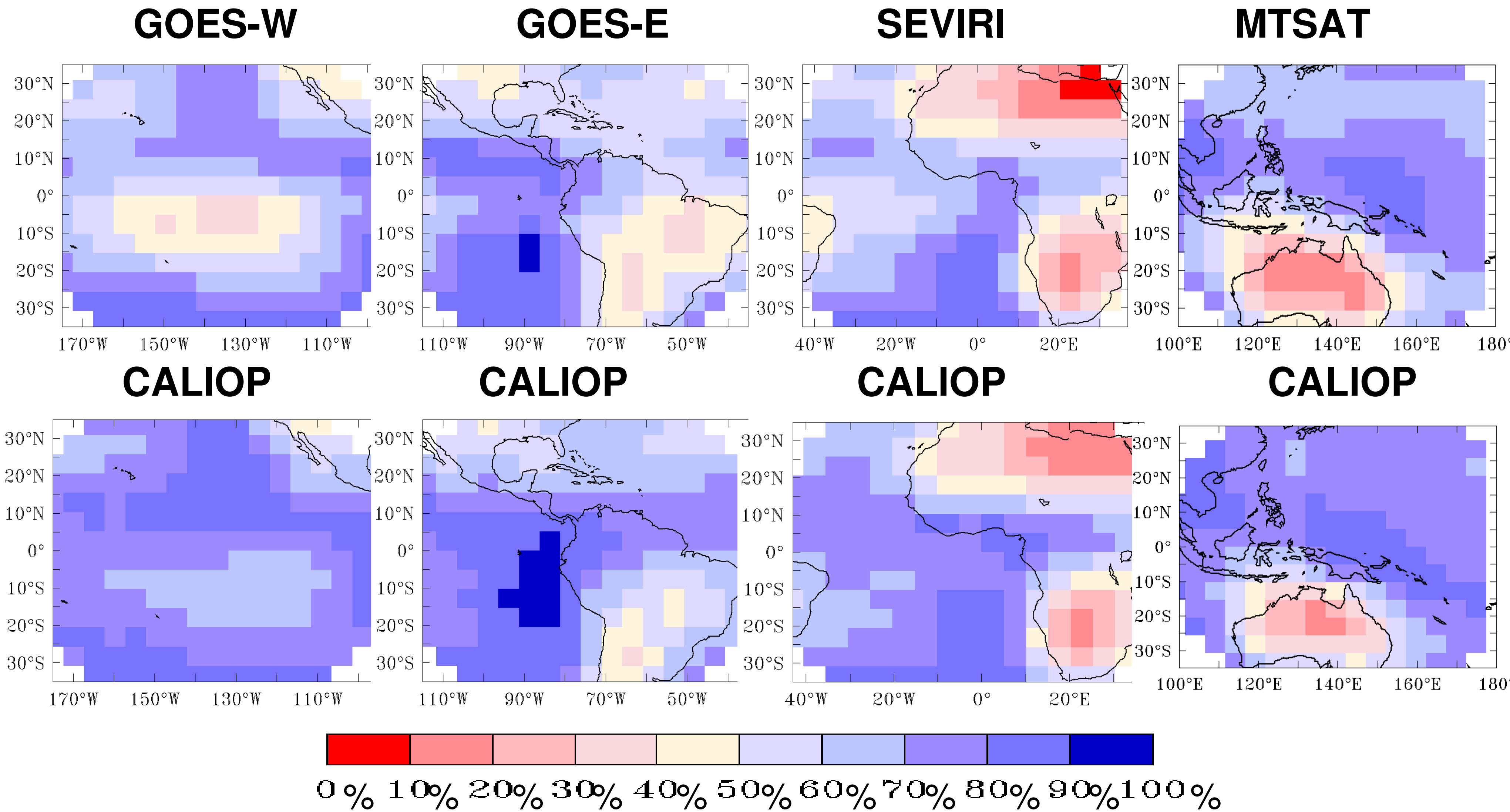
Lidar SNR smaller during daytime than nighttime.

Use of visible channels in the GEO retrievals during daytime. Solar contribution in the 3.7 channel during daytime.

CLOUD OCCURRENCE FREQUENCY MAP

1 June 2009 to 30 September 2009

Collocated geostationnary and CALIOP data



CALIOP cloud layers with optical thickness smaller than 0.1 not taken into account.

MEAN CLOUD OCCURRENCE FREQUENCY (COF)

Collocated geostationnary and CALIOP data

1 June 2009 to 30 September 2009

	GOES-W	CALIOP	GOES-E	CALIOP	SEVIRI	CALIOP	MTSAT	CALIOP
Ocean night	67%	82% +1	71%	81% +2	69%	80% +1	67%	77% +4
Ocean day	65%	71% +1	66%	68% +2	62%	66% +1	71%	70% +3
Land night			47%	57% +4	38%	44% +3	45%	56% +3
Land day			53%	69%+2	40%	48% +2	42%	59% +1

Only Geostationnary (GEO) data with VZA < 55°. CALIOP cloud layers with optical thickness smaller than 0.1 not taken into account.

Excepted over ocean during daytime, the CALIOP COF's are larger than the geostationnary COF's by more than 10%. The largest differences (15%-17%) are found for land during daytime for MTSATand GOES-E and ocean during nighttime for GOES-W.

For CALIOP, the increases in COF is between 1% and 4% when the threshold on optical thickness decreases to 0.02.

The sign of the day to night GEO and CALIOP COF variations are the same, excepted for MTSAT

Cloud cover occurrence: comparison at pixel level

	Hite Rate			
	GOES-W	GOES-E	SEVIRI	MTSAT
Ocean night	73%	77%	80%	79%
Ocean day	75%	77%	81%	78%
Land night		78%	83%	84%
Land day		74%	83%	76%

Hite Rate : rate of agreement between the GEO and the CALIOP cloud identification's

	GOES-W		GOES-E		SEVIRI		MTSAT	
	POD	FAR	POD	FAR	POD	FAR	POD	FAR
Ocean night	74%	9%	79%	9%	81%	7%	78%	10%
Ocean day	78%	15%	81%	16%	82%	12%	85%	16%
Land night			72%	13%	74%	16%	76%	6%
Land day			70%	10%	74%	11%	68%	4%

POD: rate of CALIOP cloudy scene correctly detected by the GEO
FAR: fraction of GEO cloudy scene detected to be clear by CALIOP

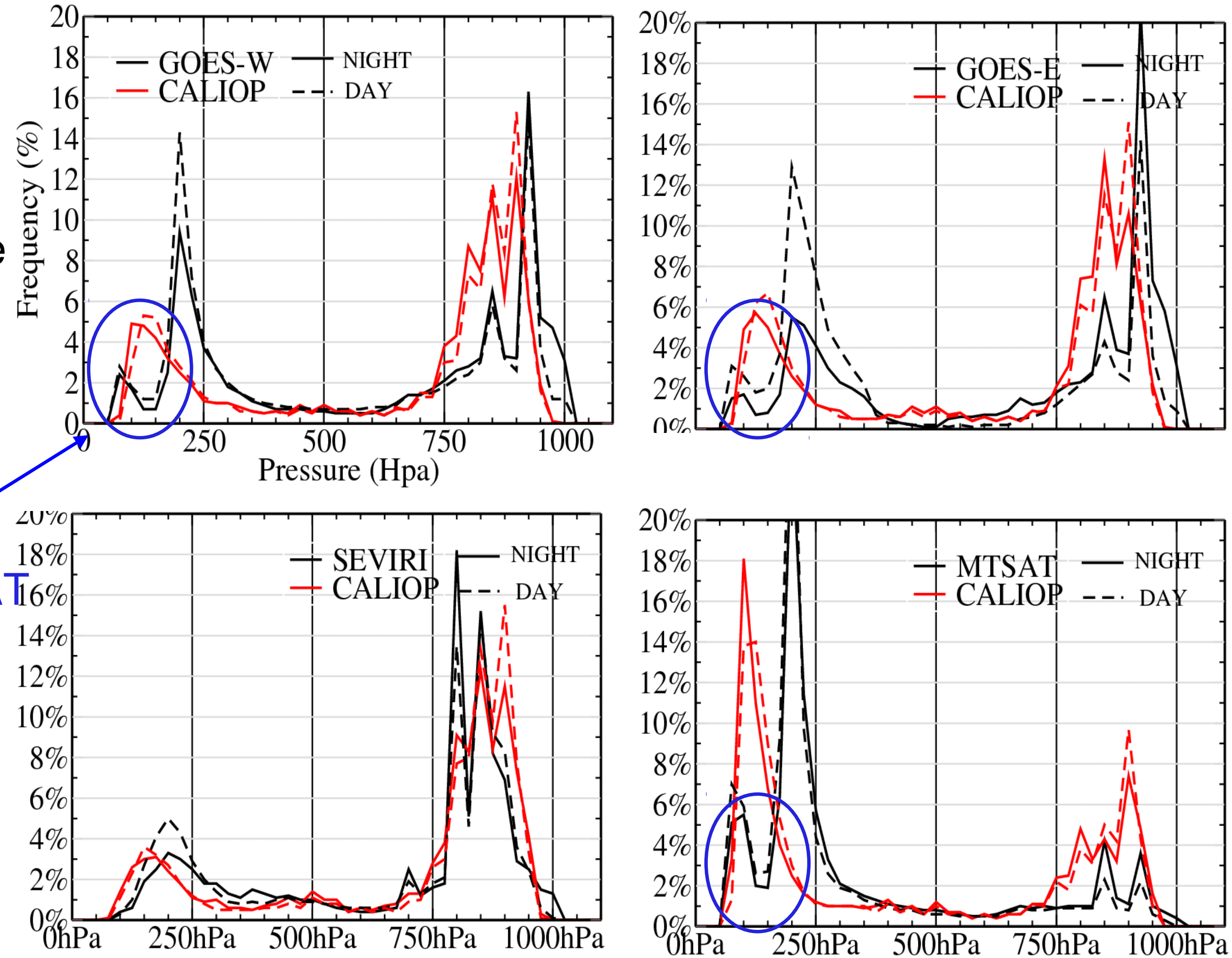
Geostationnary and CALIOP cloud top pressure distribution over ocean

Distributions normalized by the number of sample in the distribution.

Over ocean large amount of GEO partial cloud cover

No pressure available for these cases.
23% to 28% during day time.
9% to 17% during nighttime

Only one sounder channel available for GOES and MTSAT thin cirrus cloud top pressure retrieval



For CALIOP, only the top of the uppermost layer taken into-account.

Geostationnary and CALIOP cloud top pressure distribution over ocean

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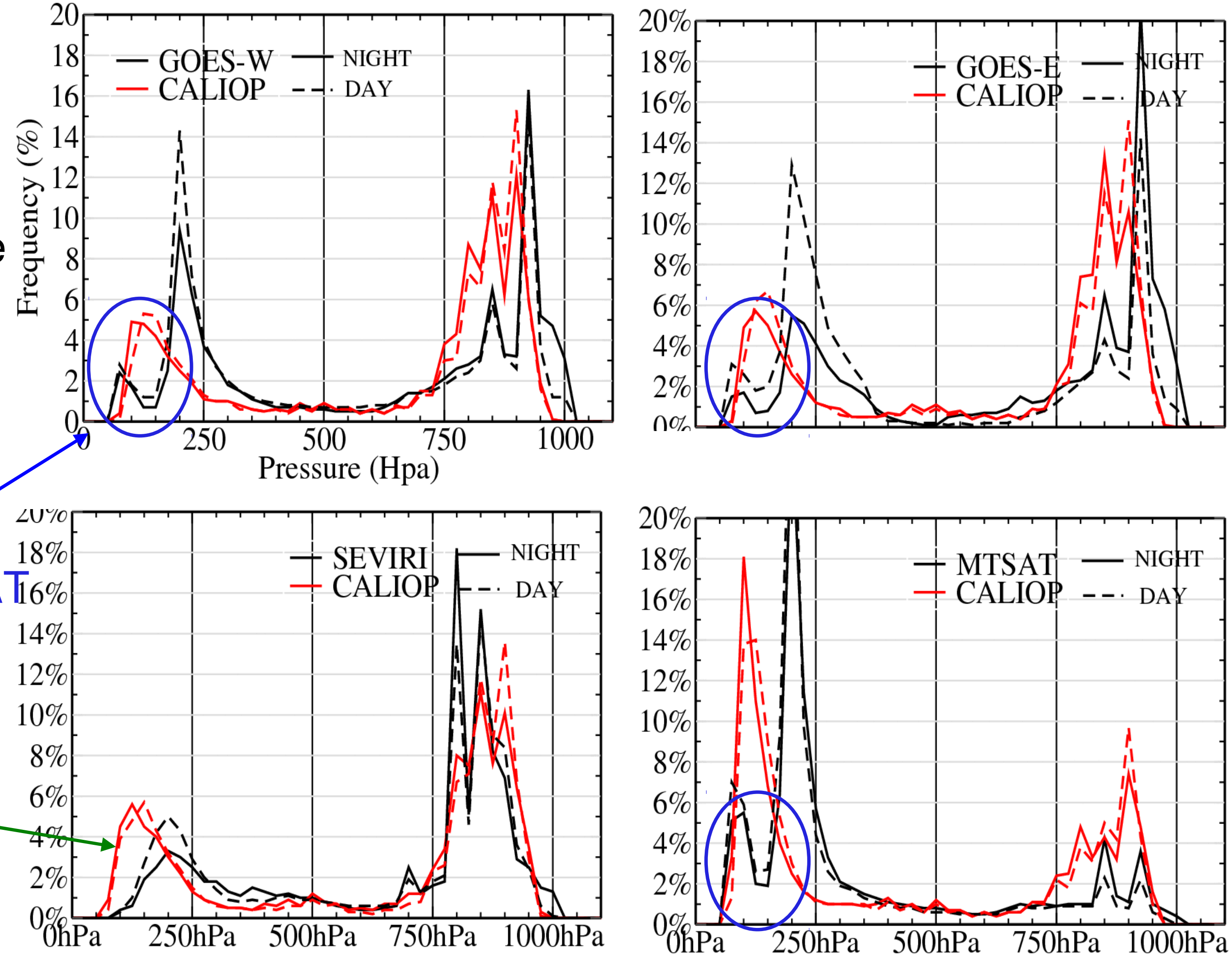
20km and 80km CALIOP cloud layer included



For CALIOP, only the top of the uppermost layer taken into-account.

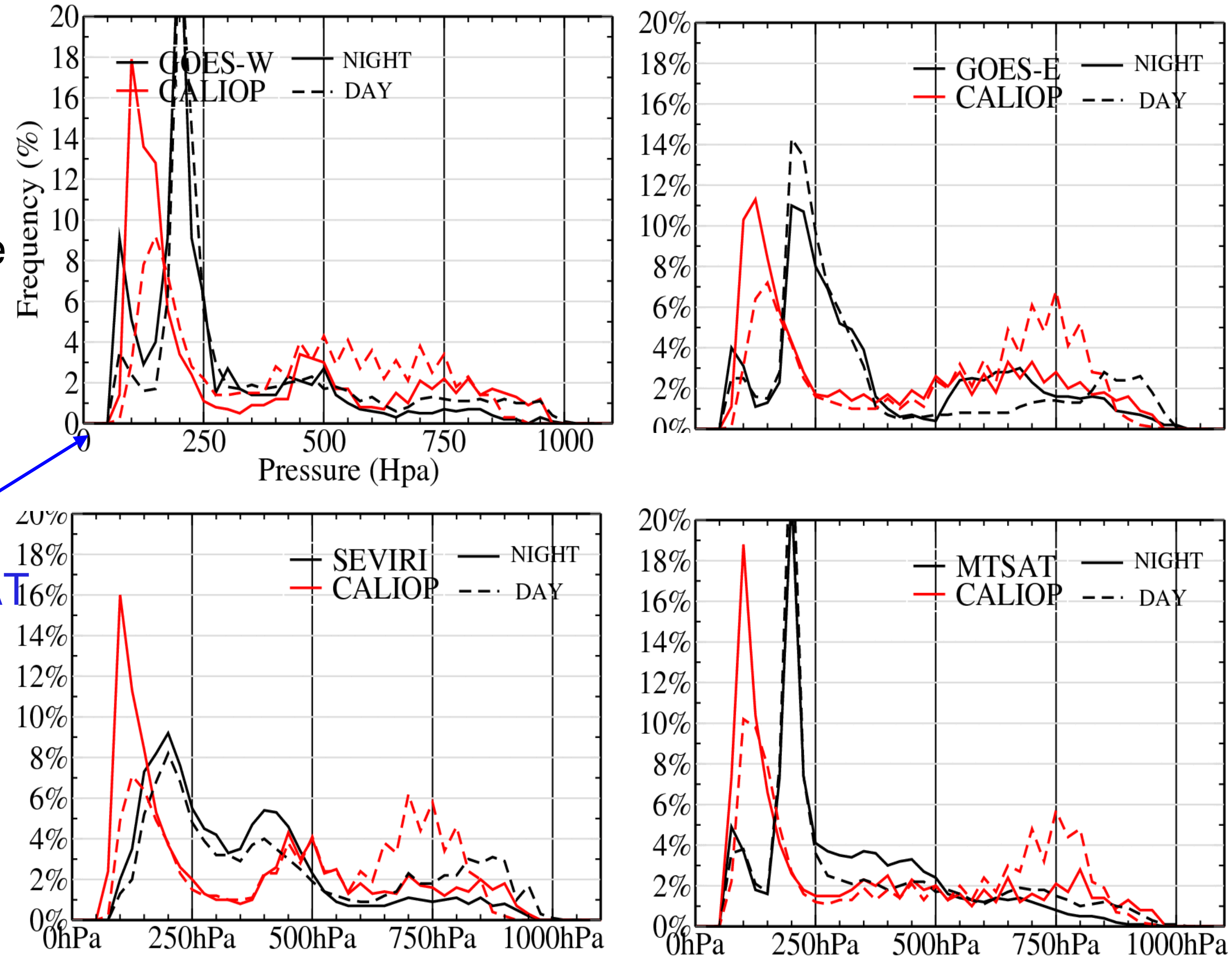
Geostationnary and CALIOP cloud top pressure distribution over land

Distributions normalized by the number of sample in the distribution.

Over land, 7% to 10% of GEO partial cloud cover.

No pressure available for these cases.

Only one sounder channel available for GOES and MTSAT thin cirrus cloud top pressure retrieval



For CALIOP, only the top of the uppermost layer taken into-account.

Geostationnary and CALIOP cloud top pressure distribution over land

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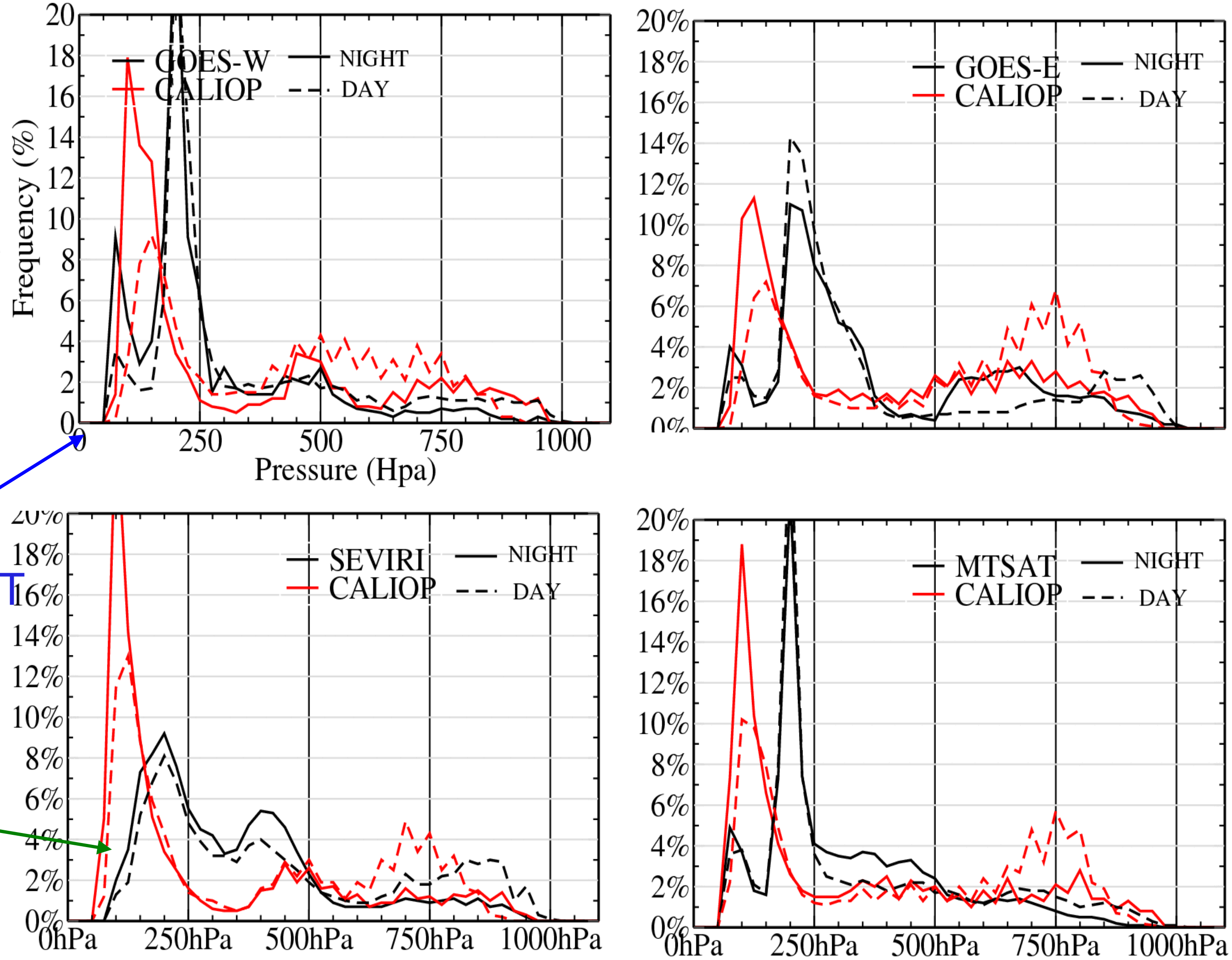
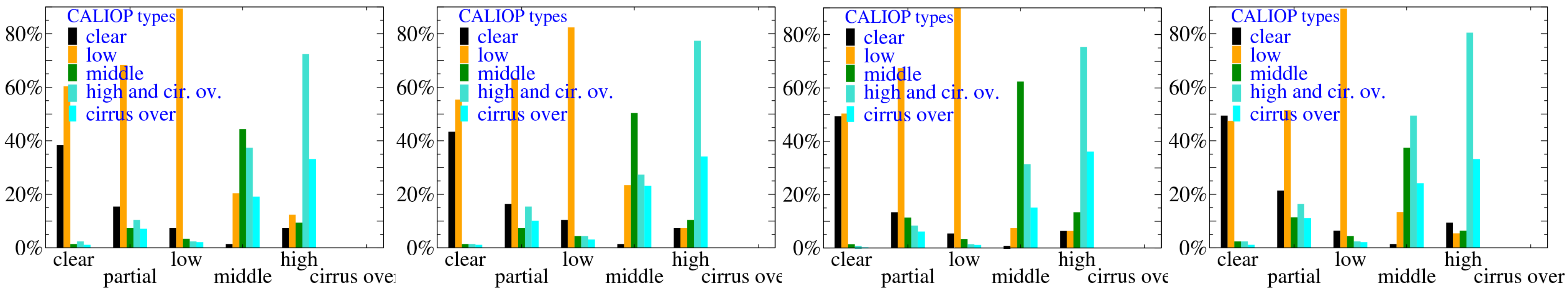


For CALIOP, only the top of the uppermost layer taken into-account.

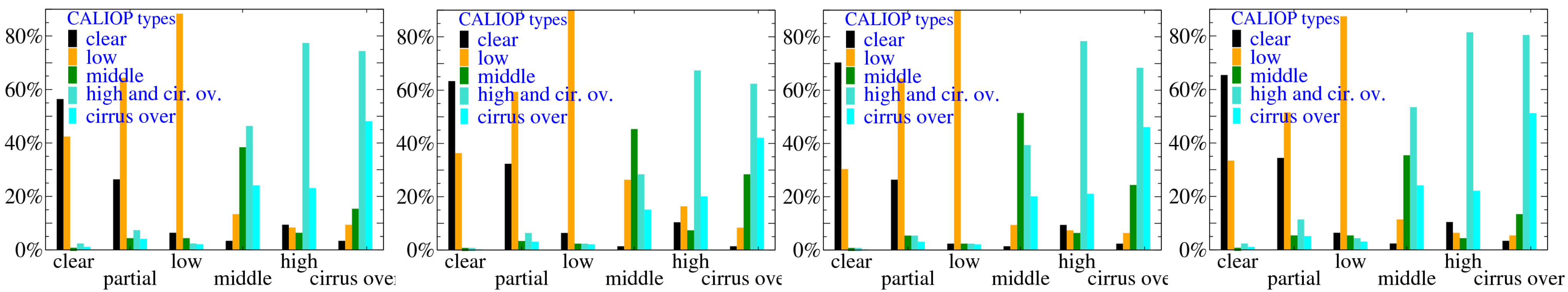
Comparison at pixel level: cloud cover types over ocean

Distribution of the CALIOP cloud types class for each geostationnary class

Nighttime



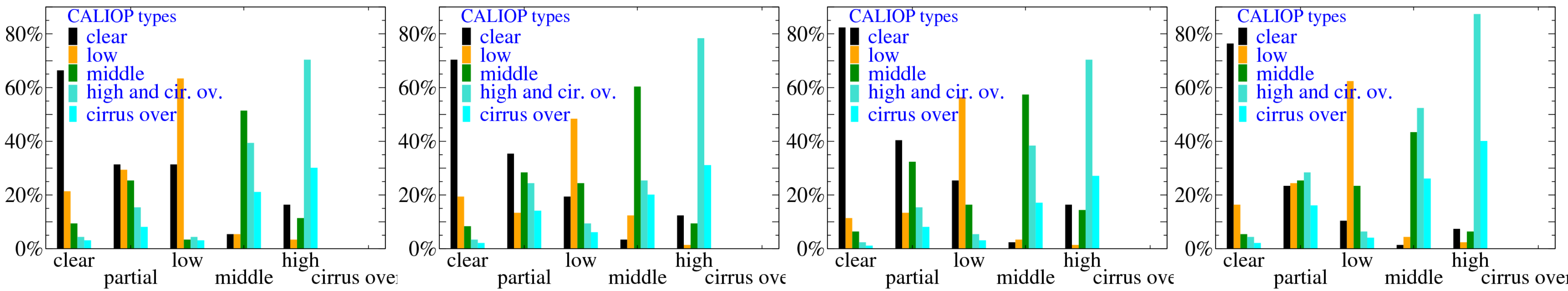
Daytime



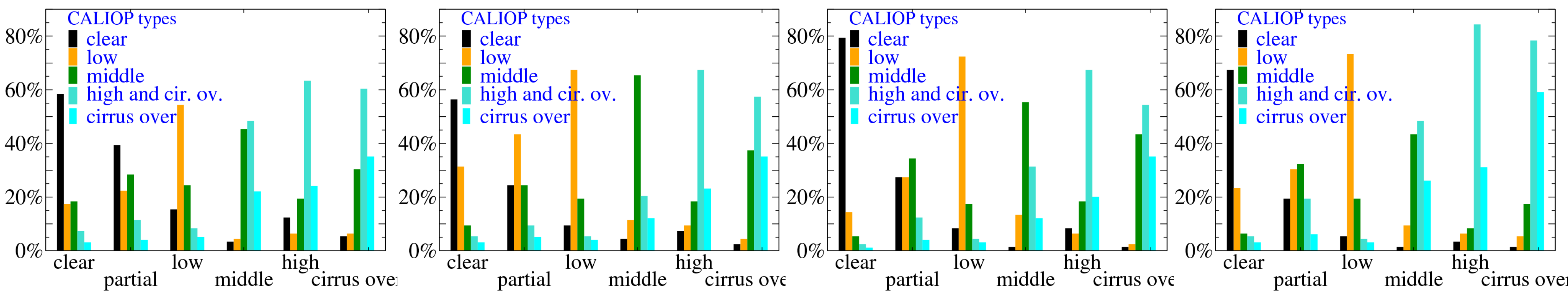
Comparison at pixel level: cloud cover types over land

Distribution of the CALIOP cloud types class for each geostationnary class

Nighttime



Daytime



CONCLUSION (1)

A first evaluation of the cloud type classification and of the cloud top pressure distribution obtained between 30°N and 30°S using the visible and infrared data of the four geostationary satellites MTSAT, GOES-W, GOES-E and SEVIRI and the SAFNWC cloud retrieval algorithm has been performed. The lidar CALIOP 5km cloud cover has been used as the reference. Night and day data over land and sea have been analysed separately for a four month period and each satellite.

The field of view of each GEO is limited to VZA < 55°. CALIOP cloud layers with optical thickness smaller than 0.1 or detected at a scale larger than 5km are not taken into account.

➔The same behaviour is found for the four GEO versus CALIOP.

Excepted over ocean during daytime, the CALIOP COF's are larger than the geostationnary COF's by more than 10%. Maximal differences (15%-17%) are found for land during daytime for MTSATand GOES-E and for ocean during nighttime for GOES-W. The sign of the day to night GEO and CALIOP COF variations are the same, excepted for MTSAT.

For CALIOP, the increases in COF is between 1% and 4% when the threshold on optical thickness decreases to 0.02.

CONCLUSION (2)

The rate of agreement (HR) in scene indentification at pixel scale between the GEO's and CALIOP range from 74% to 84%. The SEVIRI/CALIOP HR's are the highest and the GOES-W/CALIOP HR's are the lowest.

➔The lidar and geostationary pressure distribution shapes are similar.

They are peaked at high and low pressure values over ocean and at low pressure value over land. However, the geostationary low pressure peak are not so low than in the CALIOP low pressure peak.

For GOES-E, GOES-W and MTSAT the pressure distribution have a spurious peak at very low pressure which is not present in the SEVIRI distribution thanks to the avaibility of severals sounders channels . Low clouds detected by CALIOP during daytime are not well observed with the GEO's

FURTHER WORKS

On the short term this comparative analysis between the GEO's and CALIOP as a function of the GEO will be pursued. A special attention will be given to tho the day to night variation of cloud cover observed by the GEO's and CALIOP. Further on, the GEO cloud cover will be analysed over the whole diurnal cycle. The GEO's in the region of field of view intersection will be intercompared.

THANKS TO SATMOS(INSU-METEO-France), ASDC(NASA) AND ICARE(CNES) FOR THE DATA PROVISION